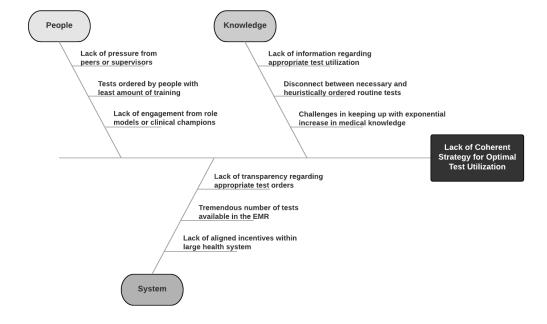
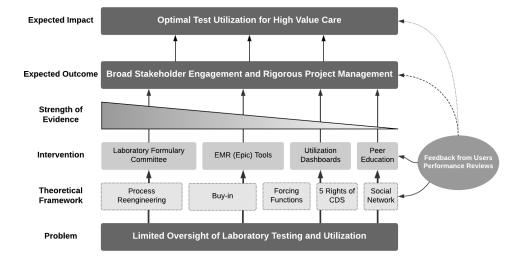
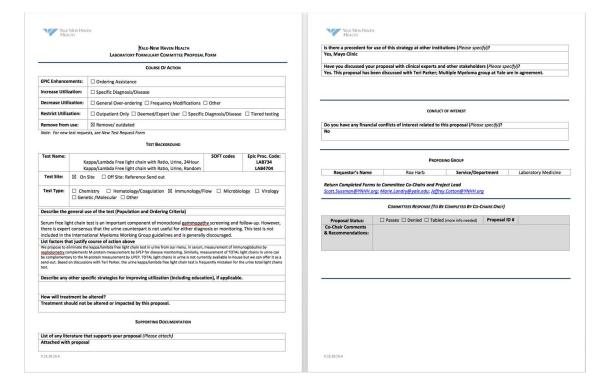
Supplementary Figure 1. Barriers to Test Utilization Management



Supplementary Figure 2. Program Theory

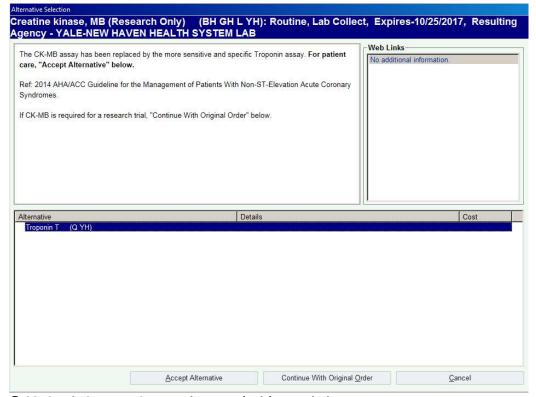


Supplementary Figure 3. Laboratory Formulary Proposal Form



An example of a laboratory proposal form submitted to the co-chairs for the removal of free kappa/lambda light chain testing in urine from the formulary. Sections include: course of action, test background, supporting documentation, and statement on conflict of interest.

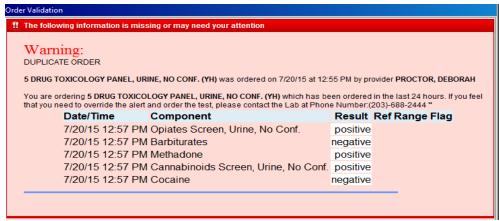
Supplementary Figure 4. Alternate Test Alert for CK-MB



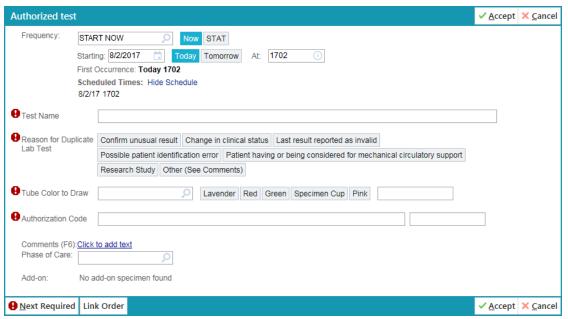
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This alert is triggered for a CK-MB order and includes a brief summary of current evidence. Providers can choose troponin T as an alternate test or cancel order for clinical testing. If they choose to continue with the original order, they are prompted to enter a study protocol number for research-related testing.

Supplementary Figure 5. Checks for Duplicate Orders and Authorized Duplicate Test



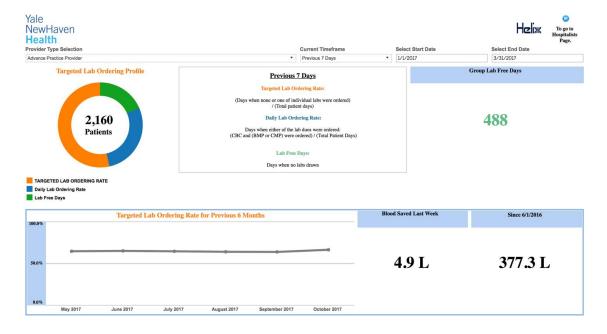
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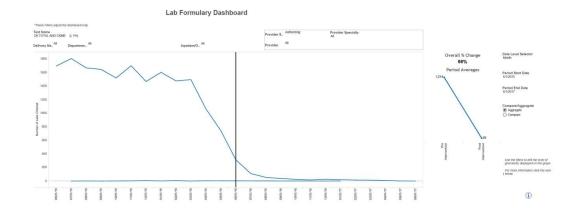
Top Panel: This check is triggered based on a pre-determined interval for duplicate testing. The trigger includes the most recent test results as well as a customer service number to call if the provider deems the override clinically appropriate. Bottom Panel: After obtaining an authorization code from customer service, providers have to enter the authorized duplicate test name as well as the reason for duplicate testing before proceeding with the order.

Supplementary Figure 6. Routine Labs Dashboard



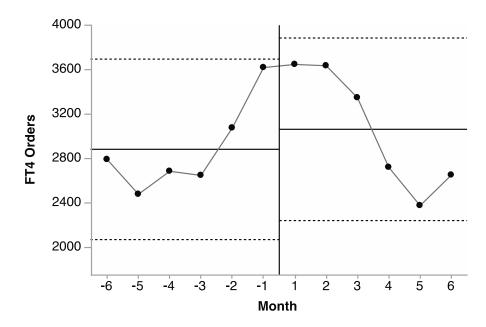
Patients are tracked separately if they are assigned to an Attending or Advanced Practice Provider (hospitalists) or Team (residents) and the data is used to calculate patient days for a given period of time. Pie chart reflects rates of daily labs, targeted labs and lab free days per patient days. Lab free days are used to calculate blood savings based on an approximate volume of 3 milliliters and 3.5 milliliters for CBC and BMP/CMP, respectively.

Supplementary Figure 7. Lab Formulary Dashboard



Screenshot of the dashboard created for tracking orders pre- and post-intervention. Dashboard allows for filtering by test name, delivery network, department, inpatient/outpatient status, as well as provider name and specialty. Solid line represents date of intervention.

Supplementary Figure 8. Free Thyroxine volume pre- and post-intervention at Yale-New Haven Health System



Individual control chart depicting Free Thyroxine (FT4) orders before (10/01/2015 - 03/31/2016) and after (05/01/2016 - 10/31/2016) alternate test alerts were created for Free Triiodothyronine (FT3), T3-Uptake and Reverse T3 on 04/01/2016. Note that there was no specific intervention targeting FT4.

Supplementary Table 1. Yale-New Haven Health System

Hospital ^a	Beds	
Yale-New Haven Hospital	1541	
Bridgeport Hospital	383	
Greenwich Hospital	206	
Lawrence and Memorial Hospital	308	
Westerly Hospital	125	
^a Greater than 120,000 discharges for the entire system		

Supplementary Table 2. Timeline of Interventions

Date	Milestone	
02/2015	Strategic planning for LFC including framework development, senior leadership buy-in and identification of key stakeholders	
10/2015	Implementation of first batch of duplicate checks	
11/2015	System-wide LFC kick off	
01/2016	Removal of FTP	
04/2016	 Alternate test alert creation for CK-MB, FT3, T3U and RT3 Implementation of second batch of duplicate checks CK-MB test modification to "Research Only" 	
06/2016	 Month-long educational sessions for hospitalists on routine lab orders 	
07/2016	Month-long educational sessions for residents on routine lab orders	
02/2017	Implementation of third batch of duplicate checks	
05/2017	Implementation of fourth batch of duplicate checks	
Abbreviations: LFC Laboratory Formulary Committee; FTP, Free Thyroxine Panel; FT3, Free Triiodothyronine; RT3, Reverse Triiodothyronine; T3U, Triiodothyronine Uptake.		

Harb R, et al. BMJ Open Qual 2019; 8:e000689. doi: 10.1136/bmjoq-2019-000689

Supplementary Table 3. Duplicate Checks for Lab Tests

Lab Test	Check Period	
Cryoprecipitate, Fresh Frozen Plasma, Platelets, Red Blood Cells	30 Minutes	
DAU, NT-ProBNP, Overdose Panel, Procalcitonin, Reticulocytes, CRP	1 Day	
Babesia/Malaria Detection and Quantitation, Blood Smear Interpretation, Ehrlichia Smear, ESR	2 Days	
C. Difficile Assay, CMV (IgG), CMV (IgM), CMV (PCR)	3 Days	
Type and Screen	3 Days	
Adenovirus (PCR), ANA, D-Dimer, EBV (PCR), Acute Hepatitis Panel, Chronic Hepatitis Panel, HHV-6 (PCR), Immunofixation Electrophoresis, Iron and TIBC, Lipid Panel, Lymphocyte Subsets, Norovirus (PCR), Protein Electrophoresis, Respiratory Viral DFA Screen, TSH	7 Days	
CMV IgG Avidity	14 Days	
Aldolase, Anti-Jo1 Antibody (IgG), BCR-ABL1 Qualitative/Quantitative, RVVT, HbA1C, Folate, HCV (Quantitative), HBV (Quantitative), HIV-1 RNA (Quantitative), Lupus Anticoagulant, Phospholipid Neutralization, Vitamin B12	30 Days	
CCP Antibody, Rheumatoid Factor	60 Days	
Myositis Antibody Panel, Scleroderma (SCL-70) Antibody, Sjogren's Antibodies	365 Days	
See Addendum A	Once in a Lifetime	
DAU: Drugs of Abuse, Urine; CRP: C-reative Protein; ESR: Sedimentation Rate; CMV: Cytomegalovirus; EBV:		

DAU: Drugs of Abuse, Urine; CRP: C-reative Protein; ESR: Sedimentation Rate; CMV: Cytomegalovirus; EBV: Epstein-Barr Virus; HHV-6: Human Herpes Virus-6; TSH: Thyorid Stimulating Hormonel; RVVT: Russell Viper's Venom Time; HbA1C: Hemoglobin A1C; HCV: Hepatitis C Virus; HBV: Hepatitis B Virus, HIV: Human Immunodeficiency Virus-1; CCP: Cyclic Citrullinated Peptide

Supplementary Table 4. Once in a Lifetime Test

Ace Polymorphism (Insertion/Deletion)	HLA-B*5701 Genotyping
Alpha-Globin Common Mutations	Huntington Disease Mutation Analysis
Alpha Thalassemia 7 Deletions	RETT Syndrome MECP2 Comprehensive Analysis
ATP8B1 Sequence Analysis	Methylenetetrahydrofolate Reductase Mutation
Beckwith-Wiedemann Syndrome Panel	NF1 and Spread 1 Sequencing
Beta Globin Gene Sequencing	Notch 1 Analysis
Biotinidase Deficiency, Gene Analysis	PAH Comprehensive Analysis
Cystic Fibrosis Gene Sequencing	PMP22 DNA Sequencing Test
CHD7 Sequencing	PYGM Full Gene Sequencing
Citrullinemia ASS1 Gene Analysis	Russell-Silver Syndrome
Connexin 26 GJB2 Sequencing	RYR1 Gene Sequencing
Cytochrome P4502C19 Genotype	Short-Chain Acyl-CoA Dehydrogenase
DMPK DNA Test (DM1)	SLC26A4 Gene Deletion/Duplication
ELA2 Full Mutation Analysis	SLC2A1 (GLUT1-DS) DNA Sequencing
Factor V Leiden	Spinal Muscular Atrophy DNA
FSHD DNA Test	THAP1 (DYT6) DNA Sequencing
Gale Gene Sequencing	TSC1 DNA Sequencing Test
GALK1 Gene Sequencing	TSC2 DNA Sequencing Test
Galt Gene Sequencing	Von Hippel-Landau Full Mutation Screen
HADHA Targeted Exonic Microarray	Wilson Disease, ATP7B Mutation Screen
HAX1 Gene Sequence Analysis	Wiskott Disease-Blood Specific
Hereditary Hemochromatosis DNA	Fragile X DNA Probe

Supplementary Table 5. Number of Duplicate Orders Pre-Intervention

Lab Test	Volume (1/5/2014 – 1/3/2015)
9-Drug Toxicology Panel, No Confirmation	54
9-Drug Toxicology Panel, with Confirmation	8
Adenovirus, Quantitative PCR	4
ANA Screen with Reflex to Titer and Pattern	8
Babesia Detection and Quantitation	20
BCR-ABL 1Qualitative with Reflex to Quantitative	2
Blood Smear Interpretation	504
Cytomegalovirus, IgG	11
Cytomegalovirus, IgM	8
Cytomegalovirus, Quantitative PCR	137
D-Dimer	187
Dilute Russell Viper Venom Time	18
Ehrlichia Smear	8
Epstein-Barr Virus, Quantitative PCR	17
Factor V Leiden	16
Folate	71
Hemochromatosis Mutation	2
Hemoglobin A1C	243
Hepatitis B Virus, Quantitative PCR	10
Hepatitis C Genotype	3
Hepatitis C Virus, Quantitative RT-PCR	13
Hepatitis Panel, Acute	8
Hepatitis Virus Panel, Chronic	18
HIV-1 RNA, Quantitative RT-PCR	9
Immunofixation Electrophoresis, Urine	2
Iron and TIBC	31
Lipid Panel	78
Lupus Anticoagulant	12
Malaria Detection and Quantitation	5
NT-ProBNP	393
Overdose Panel, Serum	63
Phospholipid Neutralization	12
Protein Electrophoresis, Urine	3
Prothrombin Gene Mutation	9
Reticulocytes	271
Sedimentation Rate	591
TSH	144
Vitamin B12	160